Renewable and Sustainable Energy Reviews 15 (2011) 2214–2221

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Potential of renewable energy alternatives in Australia

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ARTICLE INFO

Article history:
Received 2 October 2010
Accepted 24 January 2011

Keywords:
Renewable energy
Australia
Solar
Wind
Biofuel

ABSTRACT

Australia is one of those countries that are considered rich and abundant in fossil fuel energy resources. It is important for Australia to regulate the use of conventional energy and attempt replacing these conventional energies with renewable energy (RE) resources. Renewable energy resources in Australia are widely categorised as solar energy, biomass, wave energy and wind energy. By increasing the utilisation of renewable energy resources the national contribution to world wide green house gases (GHG) emissions would be reduced, at the moment approximately 50% of Australia's GHG emissions are contributed from electricity generation [Dicks, AL, Diniz da Costa, JC, Simpson A, McLellan B. Fuel cells, hydrogen and energy supply in Australia. Journal of Power Sources 2004;1:1–12] with a large proportion of the remaining emissions coming from transport and vehicular sectors. As Australia's population, as well as that of the world, continues to grow and live increasingly energy dependant lives, the future of energy supply will grow. This paper investigates the potential of renewable resources in Australia at present and the magnitude of their present and future contributions to the national energy consumption. Conclusions will be drawn from the results of this investigative scan and recommendations will be proposed.

Contents

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doi:10.1016/j.rser.2011.01.018

1. Introduction

Australia is a country fortunate to have abundant fossil fuel energy resources however the reliance on these resources has contributed to Australia having the highest green house gas (GHG) emissions per capita in the western world [1]. By increasing the utilisation of renewable energy resources the national contribution to world wide GHG emissions would be reduced whilst increasing sustainability of energy resources and reducing dependency on foreign countries. Currently 50% of Australia's GHG emissions are a result from electricity generation [2] with a large proportion of the remaining emissions coming from transport and vehicular sectors.

As Australia's population, as well as that of the world, continues to grow and live increasingly energy dependant lives the future of energy supply is growing. There are many sources of energy in Australia currently being utilised whilst many more that are yet to be taken advantage of. This chapter will investigate the potential of renewable resources in Australia at present and the magnitude of their present and future contributions to the national energy consumption. Conclusions will be drawn from the results of this research and recommendations regarding Australia's future with renewable energy will be made.

2. Fossil fuel based resources

Australia's main source of energy, both for electricity generation and transportation fuel, is derived from fossil fuel based resources such as coal, coal seam methane (CSM) gas, oil and natural gas.

As can be seen in Fig. 1, the main sources of electricity generation in Australia are fossil fuel based resources. In 2008 the renewable energy sector, shown as the exploded sections of the pie chart, produced less than 5% of the total amount of energy consumed.

2.1. Coal

According to the Australian Bureau of Agriculture and Resource Economics [3] brown and black coal fired electricity generation produced 83.7% of the total production for 2006–2007. Australia is fortunate to have vast quantities of reserved coal which will doubtless provide the majority of electricity for the coming years whilst also providing a large export commodity. For the 2007–2008 financial year thermal and metallurgical coal worth AUD$24.1billion [3] was exported to Asia, Europe, South America and Africa whilst also providing employment for 20,000 people [2]. Whilst advantageous due its capacity and relative cost efficiency a major downside to using coal as a major energy source is its contribution of 30% of Australia's total GHG emission whilst the large export quantity also contributes to a significant proportion of world emissions.

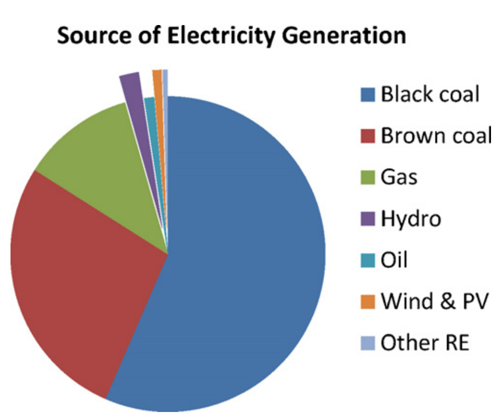

Fig. 1. Australian electricity generation by resource [3].

The life of Australia's coal deposits has been estimated by British Petroleum (BP) [4] to be around 261 years based on consumption increasing with population models, whilst other sources [2] have suggested that it may be as much as 500 years. The variance in these estimations is generally a factor of the different assumptions made due to the fact that all of Australia's coal reserves have not yet been found so it is hard to adjust an estimate to cover this unknown. The original figure calculated by BP is found from current proven reserves and assuming constant yearly increased of energy at approximately 4%.

2.2. Natural gas

Two thirds of natural gas production in Australia is from the Carnarvon Basin and the north west shelf of the coast of northern western Australia [3] with Australia's LNG export commodity valued at over $5.9 billion. Following petroleum and coal, naturally occurring gas is the third most utilised energy resource and therefore a significant contributor to the countries GHG emissions. The portion of the gas that is used in the national market is generally used for large scale electricity generation and domestic space and water heating.

Reserves of natural gas both in Australia and our maritime and coastal economic zones are estimated to be around 2.41 trillion m^3 from which 38.3 billion m^3 per year is removed as of 2009 [4].

2.3. Coal seam methane

CSM is a methane based natural gas regularly found in the porous structure of coal deposits and can be utilised as a source of energy, generally for electricity generation. The gas is a primary fossil fuel in that it formed thousands of years ago when the carbon containing organic material was forced by natural means to undergo coalification [2]. Until the commercial value of CSM was discovered it was often vented to the atmosphere as it was unsafe in underground mines due to the risk of explosion and breathing difficulties. The vented gas being a hydrocarbon based fuel was an unnecessary emission and by capturing the gas and combusting it the emissions are reduced and work, heat or electricity can be created from effectively nothing as the resource was not being utilised. Currently the main use for CSM is either to provide power on an industrial scale on site or in the commercial generation of electricity for consumers.

CSM accounts for 7.3% of Australian gas production with the majority being sourced in Queensland where it accounts for 87.7% of the states gas production [3]. Where it was once allowed to escape from the coal mining operation directly into the environment it is now being captured and used as an electricity feedstock in QLD and NSW. CSM specific power stations are becoming more

prolific in recent years with the construction and commission of the 365 MW Swanbank 'E' power station [2] as well as others being planned for construction in the near future particularly in QLD where the vast majority of CSM is found.

CSM based projects have been funded in Queensland by the public sector to value of over $1.4 billion up to 1998 with many projects still underway [2]. Origin Energy is heavily involved in the future of CSM in a power generation scenario and has therefore invested heavily in experimental projects through to full scale power stations.

2.4. Oil/petroleum

According to BP statistical data [5], in the year 2008 Australia produced 23.8 million tonnes of oil from reserves however for the same year 42.5 million tonnes were consumed. This leaves Australia in the position of being a net importer of oil. The cost of a highly distributed national population and the ease of affordability of owning a vehicle have taken its toll on proven reserves which are estimated to last until approximately 2018 at current production capacity [2]. The dependence on imported transportation fuels have left Australia in an awkward position as whilst we have a plentiful supply of power generating fossil fuels and also great potential for renewable energies, the volumes of fuel required for the growing amount of vehicles mobilised is simply not available for the long term.

2.5. Nuclear

Australia does not currently produce electricity using nuclear technology the countries large reserves of uranium are mined and the then exported as a uranium rich ore to countries that require the fuel. There are many social, political and environmental reasons against nuclear power with the major boundaries faced being the problem of disposing of radioactive nuclear waste and possible more importantly the natural abundance of coal which is simpler to utilise with current infrastructure.

2.6. Future of fossil fuel

The current estimated lifespan of proven reserves of fossil fuels by Dicks et al. [2] was found to 261 years for thermal and metallurgical coal as well as CSM which is a by product of coal mining and generally produced concurrently, 77.9 years for naturally occurring gases and 14 years for oil/petroleum. The former three resources are significantly higher than the global estimates of 216 and 61.9 years respectively leaving Australia in a strong position for future fossil fuel based electricity generation. However for transportation fuels the demand for resources is significantly higher than the local supply leaving the country in a net import scenario and with limited natural resources.

3. Mandatory renewable energy target (MRET)

In the year 2001 the Howard government implemented a mandatory renewable energy target, herein MRET, to attempt to motivate the nation to place a greater emphasis on developing and implementing renewable sources of energy to combat climate change and reduce GHG emission. The MRET functions by introducing a tradeable commodity certificate known as the REC or Renewable Energy Certificate equivalent to 1 MW h of electricity generation from a certified renewable energy source. The implication of financial and economic gains to parties utilising renewable energy would attract the commercial world to the use of renewable energy whilst a subsequent section of the MRET involved placing a "legal liability on wholesale purchasers of electricity to proportionally contribute to an additional 9500 GW h of renewable energy per year by 2010" [6].

4. Renewable energy in Australia

With a world overly dependent on dwindling fossil fuel resources and with a new appreciation of the damage caused by green house gases, it is becoming more and more evident that renewable energy resources must be utilised to create a sustainable future. Renewable energy has been defined by Sorensen [7] and more recently of Bolyle [8] as "Energy obtained from the continuous or repetitive currents of energy recurring in the natural environment which are replenished at the same rate as they are used".

Renewable energies can be broken down into those where the sun is the source of the energy (Solar Energy) and those where it is from another source (Non-Solar Energies). Solar energies include biomass, biofuel, solar power, hydro energy and wind energy. Renewable Non-Solar energies include tidal energy and geothermal energy [9,10].

4.1. Biomass and biofuel

Biomass, for the energy production industry, is any material that was once a living organism that can be used in the production of renewable energy such as wood, methane producing waste, sugarcane, leaf litter or trees such as palms and dates as well as eucalyptus [11]. Biomass can be converted to biofuel using several different methods depending on the type of biomass and the type of fuel required. Biomass is generally burnt as a raw product to generate steam to power turbines for electricity generation, such as in the sugar cane industry, whilst biofuel is generally used as a fuel for heating and for use in internal combustion engines rather than for electricity production. Biofuel's are generally seen as a more valuable source of energy when compared to biomass due to the higher energy density and lower moisture content. The higher moister content in biomass reduces the combustion efficiency as a fuel as when it is combusted, energy must be used to heat the water and evaporate it.

Whilst the energy density of biofuel is typically 3–4 times higher than that of biomass, it requires energy to produce it from the biomass [10]. As a result of the higher energy density biofuel is a more widely produced as a consumer fuel due to lower transportations costs. The most widely utilised biofuel in Australia is the use of ethanol blended gasoline and biodiesel which is available Australia wide.

E10, as it is commercially known, is a blend of conventional petroleum with a 10% by mass component of ethanol. It is widely distributed by mainstream petrol companies and due to its discounted price relative to conventional petrol it is very common especially in Queensland where a large majority of ethanol is produced.

The ethanol component of the fuel is effectively carbon neutral in comparison with the gasoline component as during the life of the biomass, generally sugarcane, used to create the fuel the same amount of carbon that is released in combustion is absorbed from the atmosphere during the life of the plant due to the cycle of photosynthesis. Mathews [12] suggests that the Kyoto protocol based method of reducing carbon emissions is inefficient with the largest environmental gains to be as a result of sequestering current airborne carbon. Whilst there is not an easy way to remove airborne carbon, the sequestering of solid carbon in the biomass is relatively easy. During the production and combustion of ethanol the cycle is effectively carbon neutral as the entire carbon content of the

biomass is not converted into fuel. The remaining biomass can be converted to the charcoal like biochar which can be returned to the soil where the biomass originated therefore improving soil fertility, vitality and leaving the ethanol production and combustion cycle carbon neutral [12].

Considering ethanol to be carbon neutral on average E10 has only 90% of the effective carbon pollution into the atmosphere as an equivalent amount of straight gasoline. This is a massive reduction in the release of green house effect causing emissions of an internal combustion engine.

The percentage component of E10 for the first stage of ethanol rollout has been set at 10% as it is suitable for the vast majority of the cars currently on Australian roads. It is immediately suitable as a direct replacement for gasoline fuel in all post 1992 electronic fuel injection equipped vehicles and can be run in most carbureted vehicles though occasionally the tuning or the carburetor must be slightly changed. Ethanol is only unsuitable for some highly tuned or modified vehicles with very high specific (kW/L) power engines such as modified late model turbocharged vehicles of high performance motor bikes. As ethanol is very similar to gasoline in the manner in which it is combusted, with simple modification to the fuel injection system and the basic injection and ignition timing tuning modern engines will run in a perfectly normal manner [13].

In several European countries such as England and France E20 fuel is commonplace and is suitable for use with modern cars, less than five years old, which were designed with the fuel in mind and can use it as well as conventional gasoline fuels. In Sweden and in the midwestern states of the United States of America where corn and other ethanol friendly crops are in abundance E85 fuels are common. However for this scenario the vehicle must be modified in a manner that renders it unable to be use gasoline as a fuel. Aside from the timing and tuning changes necessary to ensure the engine runs as efficiently as possible the engine and fuel system must be altered to prevent the E85 fuel from coming into contact with magnesium, aluminium and rubber components which would face unwanted corrosion and wear due to the extra corrosive nature of the fuel relative to gasoline.

Around 170 million l of ethanol is produced each year in Australia with around 90% of that being used in gasoline/ethanol blends [5]. Ethanol and biodiesel as well as the rest of the biofuel's will provide a long term benefit to Australia and so long as it is produced in a sustainable and responsible manner will continue to be a major part of Australia's energy future.

5. Biofeul production

The energy stored in biomass is from the absorption of solar energy during the life of the organic material. The methods of extracting the energy from the biomass can be from thermochemical conversion, biochemical conversion or direct extraction via crushing. Thermochemical conversion includes direct combustion where the biomass is burnt to provide heat which is generally used to produce steam to power a turbine for electricity generation [9,10].

5.1. Gasification

Gasification is a mainly chemical process that involves producing a gaseous fuel from a solid source. The basic premise is to have the solid fuel react with steam and oxygen in an environment where the volatile gasses produced can be collected. The reaction does not occur easily so condition of temperature close to 1000 °C and pressure up to 30 atm is used to make the reaction viable and relatively quickly. The resulting gas will be a mixture of mainly carbon monoxides and hydrogen, also with smaller components of methane and other combustible gasses. The relative concentrations of the gasses depend on the composition of the solid fuel and therefore so does the energy content of the gas. Generally the gas produced has approximately 10% of the energy in and equivalent volume of methane. The gas produced is generally used for small scale electricity generation however is not widely used in Australia.

5.2. Pyrolysis liquefaction

Pyrolysis is the oldest and simplest method of processing one fuel to produce a better fuel and it can be used on both unrefined solid fuels as well as waste material. The technique involves heating of the initial fuel and collecting the volatile components released in this process and then generally condensed into a liquid as the name suggests [8]. The final product is a bio-oil that has good properties for use in heating or power generation or it can be further refined to make it suitable for use as biodiesel [14].

5.3. Anaerobic digestion

As a product of biofuel production methane is one of the most useful fuels for multiple uses. Most organic material's containing carbon, hydrogen and oxygen can be decomposed by certain fungi and bacteria in the presence of water to produce methane. The waste material is converted into slurry with between 90% and 95% water. The slurry is then left to decompose in a warm environment with either fungi or bacteria. It is possible to achieve an energy efficiency of up to 90% during the process though it is generally run at less than this to quicken the process to make it more commercially viable [8].

The digestion equation can be simplified as;

$$C_6H_{12}O_6 \leftrightarrow 3CO_2 + 3CH_4 \quad (1)$$

For the digestion of a simple sugar molecule.

This process can be applied to many different scenarios for processing many types of material such as animal waste, organic material leftover from other processes as well as landfill and garbage. To hasten the reaction the temperature is often increased above room temperature however it cannot be raised to high as to kill the living bacteria and fungi performing the decomposition.

5.4. Fermentation

Similar to anaerobic digestion fermentation is a biochemical process where a living organism is used in the production of a useful fuel from a supply of biomass. The fermentation process uses various sugars to produce ethanol which can be used either as an additive to other fuels or as a fuel by itself. The decomposer that supports the fermentation process is yeast, which is a microorganism, classified as Saccharomyces cerevisiae. The yeast can only survive and function up to an ethanol concentration of around 10% after which it is killed and the process ends.

The chemical fermentation equation for a sugar molecule for ethanol production is given as;

$$C_6H_{12}O_6 \leftrightarrow 2C_2H_5OH + CO_2 \quad (2)$$

The reaction takes place in an aqueous environment. Although the water fraction is not involved in the reaction it dilutes the reaction and supports the bioorganic organisms necessary for the reaction to take place.

The bulk mixture is then distilled using traditional distillation processes to remove the water and other unwanted components. In Australia the process is widely used in the production of ethanol which is used in large volumes as a fuel supplement. The source of the sugar is generally either the unrefined sugars remaining from the production of table quality sugars or crops purposefully

grown for the purpose or fuel production. The findings from further research into the production of ethanol are presented in Section 4.

5.5. Extraction

The most basic biofuel production method is extraction. The extraction method involves crushing plant matter such as oil seed rape and canola to produces a basic vegetable oil. Through the process of transesterification this oil can be converted into biodiesel. Transesterification is a complex chemical process though the principle is the addition of ethanol or methanol to the vegetable oil. This addition converts the triglycerides into esters of ethanol or methanol as well as free glycerol, which is then removed and used in other processes [9,10]. The biodiesel can then be used in a conventional diesel engine with no modifications.

5.6. Utilisation and potential

Biodiesel is available in several locations around Australia and many farmers and other self sufficient operations produce biodiesel on a small scale for their own personal use. Biofuel in the guise of E10 fuel is completely available Australia wide at service stations and garages, with several sites in south Australia providing E85 fuel to rural customers. The future potential for biofuels is very bright with ongoing research investigating the use of different feed stocks that do not clash with the existing agricultural dedication to national food supply.

6. Solar energy

There are several different methods of harnessing the energy from solar radiation from the sun. These are active solar heating, passive solar heating and solar engines for electricity generation. Active solar energy use is normally used for domestic heating or water heating such as solar hot water systems that are common across Australia due to the low cost of running and government subsidies offered. Whilst this method of capturing solar energy can reduce electrical consumption, these types of systems are generally not used in large scales and have inherent efficiency and cost problems [9,10]. Passive solar heating is more about improving the passive efficiency of housing and other buildings. This includes passive heating devices that use the energy in solar radiation to heat a building and circulate the cold air out from the room. This includes Conservatory, Trombe wall and direct gain type applications [11].

The most relevant source of solar renewable energy with regard to electricity generation is the solar heat engine. Generally reflective mirrors are used to focus the radiation onto a source of water or other fluid then by evaporating the liquid the steam is used to in a turbine to power a generator. There are many types of plant outlay with different arrangements of focusing the radiation. 90% of USA's current [4] solar generated electricity comes from a single plant in the Mohave Desert [9,10]. Utilizing 9 different Solar Electricity Generating Systems (SEGS) rated between 13 and 80 MW [9,10]. The largest of the plants uses 46,4000 m^2 of collector area arranged in parabolic troughs focused of tubes of fluid. The working fluid used is synthetic oil that is heated to 390 °C before being used to create high temperature steam in a heat generator. On an average day the plant operates at around 17–18% total energy conversion efficiency [9,10].

From Fig. 2, northern and central Australia could prove to be a good candidate for solar energy gathering though due to the size of the array needed and the power transmission infrastructure the idea is prohibitive on a cost basis and is not commercially viable until more improvements in the technology have been made.

In 2002 830 GWh of solar energy was gathered in Australia although the majority of this, 61%, was used purely as domestic

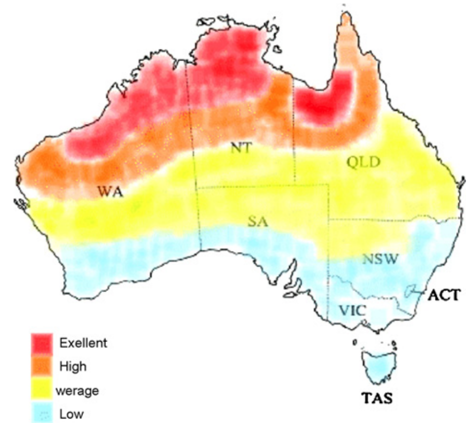

Fig. 2. Potential sites suitable for solar electricity generation [3].

solar water heating [14]. Therefore as of 2002 only 36.5 MW of power generated from solar energy was fed in to the national grid [15]. Further ABARE data has shown that this figure has risen to an electricity generating capacity of around 71 MW in the year 2007.

Solar energy has great potential for electricity generation due to large areas of inland desert with high average temperatures year round and low percentage of cloud cover and rain. The infrastructure however necessary for such projects would require a large amount of capital and the cost per unit of electricity generated is generally higher than other fossil fuel based on renewable energy sources. The secondary main problem is the transmission infrastructure which would be a significant added cost as a result of the remoteness of the deserts in Australia and the distances between prospective sites and the population centers where the current power grids exist.

7. Hydro power

Hydro generated power utilises the potential energy of water that is otherwise not used to generate electricity. The energy is sourced from the precipitation due to evaporation and the natural rain cycle which places water at high altitudes leaving it with potential energy. This natural supply of water is required for drinking water in capital cities and is often stored in dams and then released as it is required. It is now a common procedure to incorporate a hydroelectricity plant at these sights as the cost of the power plant is generally small compared to the dam construction and will provide a significant quantity of electricity over its lifespan.

The energy conservation principle of hydro power is that the water stored in storages, such as dams, is generally at a higher point then the end source where the reservoir meets the turbine. The height difference in the water column generates a pressure differential leaving a high pressure water source at the lowest point. Typical water column height is in the region of 20–30 m [9,10]. The pressure difference in the water is used to generate a forceful flow of water which when used to rotate a turbine generates a reliable and controllable supply of renewable electricity. Importantly though if the energy is not needed in the grid at the specific time it is easier to stop the production then in a coal fired of gas fired station. This is a helpful characteristic to any power grid as there is generally no capacity for storage of electricity once produced.

The amount of naturally occurring sites suitable is an important factor in the amount of hydro electricity that can be produced. There are many current sites being used and several under development however the amount of electricity produced is a function of the amount of water being required by the populations for which the dams have been created. This means there is a finite amount

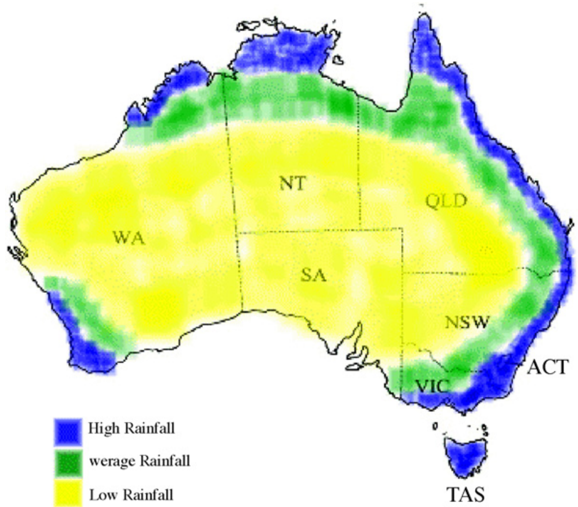

Fig. 3. Average rainfall in Australia [3].

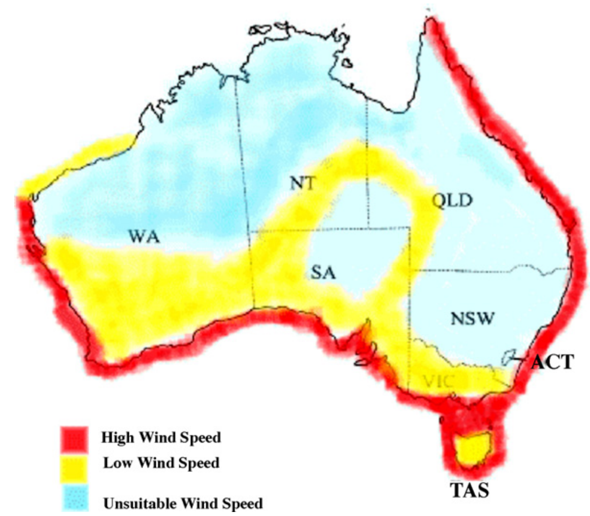

Fig. 4. Australia potential wind speed [3].

of electricity production potential. Above indicates areas of high rainfall suitable for hydro power generation (Fig. 3).

NSW and Tasmania are Australia's largest producers of hydro electricity with a capacity of 4275 MW and 2276 MW respectively which combined is 83.8% of the total national hydro electricity capacity of 7814 MW [2]. New South Wales Snowy Mountains Hydro scheme utilises a total of 31 turbines and multiple water sources and dams which when combined have an electricity generation capacity of 3756 MW of power which over the year of 2008 generated 4500 GW h. This is a large portion of the energy generated by the state and a significant portion of the renewable energy used to generate electricity. Hydro power is the most widely used renewable resource contributing 6.1% to the national electricity consumption which represents 93.8% of the total electricity generated by renewable sources [2]. The number of suitable sites needed to further develop hydropower is its greatest limitation towards growth and without suitable location the only increases in production will be as a result of improvements in efficiency of the individual power plants. Hydro power in Australia contributes a valuable contribution to the national energy production and with the supplement from new and emerging renewable technologies the MRET target should be achievable.

8. Wind power

The idea of using wind to produce work is not a recent concept with traditional windmills being used to pump water and grind flower for centuries. With the advent of more efficient generators the wind turbine has been used to generate electricity from the wind and is a promising source of renewable energy.

Wind farms have become a genuine viable option for providing renewable energy on a large commercial scale. Whilst having great potential for production, the chosen site is the most critical factor for development. The wind must be at a level high enough to power the turbine efficiently though not too high that it over powers the turbine and is dangerous to the integrity of the structure. The site is generally chosen after using either Weibull or Rayleigh parameters of the wind direction and velocity distribution [9,10]. The height of the wind turbine is a further factor that affects the suitability of the site as the Earth having a boundary layer of approximately 450 m [14], significantly higher than a turbine will generally be built. After a detailed statistical analysis of the data gathered it can be assessed if a suit has the correct characteristics for wind generation however there is further limitation such as nearby populations to the site. Wind turbines create a low frequency sound which is disconcerting to residents and the shadows cast by the blades in the morning and late afternoon are reported to be a cause of sea sickness and nausea for people in the vicinity. The final limitation to the technology is the fact that the most suitable sites are found close to the ocean as the boundary is thinner and the wind is generally faster and more consistent. As with most countries the majority of the population live close to the coast line resulting in less suitable sights and higher costs of development for other and suitable sites.

Fig. 4 indicates that the majority of the coast line at lower latitudes produces between 8 and 10 m/s of wind. Generally 8 m/s is suitable for a wind farm though a more detailed statistical analysis must be undertaken to determine the statistical properties of the wind [9,10]. In areas with suitable wind profiles a wind farm is an excellent method for generating substantial amounts of energy. In Albany, in western Australia, a single wind farm with twelve 1800 kW generating capacity produces enough power for 75% of its population of 30,000. Whilst Australia's largest wind farm on the Yorke Peninsular has a total capacity of 91 MW and can supply enough electricity for 55,000 average houses in the area [4]. In Australia given the appropriate economic investment future projections suggest that the importance of wind generated renewable energy will grow as will its capacity to produce energy. The current, 2002, wind generation is 4 PJ though it is expected to have grown to 14 PJ by 2010 [14].

9. Geothermal

Whilst no electricity generated from geothermal sources in entered into any power grid the method has potential to be a significant part of the future of Australia's energy future. The basic principle of geothermal power is to use the heat source of the Earth's crust to either heat water for domestic applications or more importantly to create superheated steam for used in a steam operated power plant for electricity generation. The technology has been widely developed with many countries producing large amount of electricity however is best suited to countries where the heat source is relatively close to the surface. The method of gathering the energy is relatively straightforward with a minor bore hole delivering water to the heat source, ideally 453–523 K, whilst a major bore hole removes the pressurised steam produced and uses is as a feedstock for a conventional steam turbine [9,10].

The chosen site for a geothermal plant is critical as the dual need for both high temperatures at a low depth will need to be satisfied

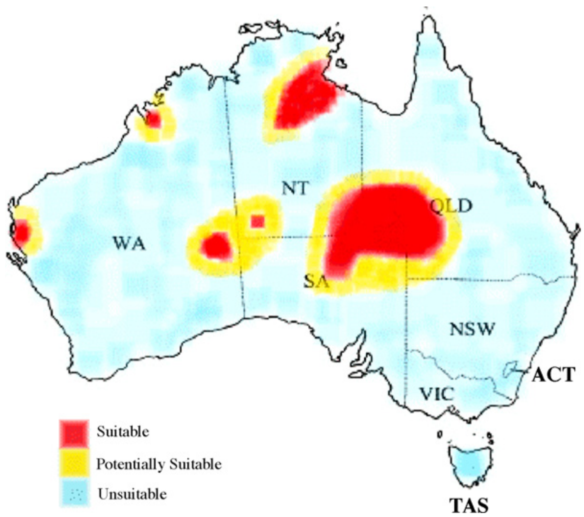

Fig. 5. Geothermal potential of Australia [3].

as well as the requirement for porous rock. Generally renewable energy is defined as being a flow of energy such as wind, precipitation or solar radiation whilst fossil fuels are generally seen as stores of resources. By this definition geothermal is not strictly seen as renewable as it is a store of heat energy that has existed since the creation of the earth, whilst not seen as a fossil fuel as it was never an organic matter, does not produce GHG and is not a physical resource such as coal or oil [9,10]. However due to its lack of emissions and sustainability it is often classified as a renewable energy. It is defined a sustainable because of the volume of the Earth's core and the magnitude of the heat produced. It is a commonly held belief that energy of the heat of the earth could be used for centuries without making a measurable change in the heat of the earth's core [9,10]. The output for a certain flow rate of water will decrease with time as the energy of the heat source is taken [11]. However if the site is left for a period of time without further energy removal it will recover to the same temperature as it was before it was 'mined'. Below indicates some of the possible sites around Australia (Fig. 5).

Until recently most geothermal infrastructure has been focused on areas near the edge of tectonic plates where the depth of the wells necessary is a lot shorter making the project s more viable. With improvements in technology, specifically in the drilling of the wells and the associated lower cost geothermal energy is becoming more and more commercially viable [9,10]. Until recently attention has been focused on areas where the geothermal source has already its own source of water and the rock is highly porous. Current trials are underway in the Cooper Basin in Australia into thermal energy from hot dry nonporous rocks designed and built by Geodynamics Inc. Geodynamics 2007 annual report suggests that when completed the Cooper Basin the plant will produce more than 500 MW at a cost of around \$45–50 (2005 prices)/MW h which is only slightly higher than that of coal or gas and significantly cheaper than the majority of other source of renewable energy.

If the trial plant built by Geodynamics Inc. in the Cooper Basin is successful it is possible that geothermal energy could receive funding from government and resources from the private sector that will result in the construction of more plants and help to secure the future of renewable electricity generation.

10. Hydrogen

Whilst hydrogen is not a renewable energy it is the most abundant element in the universe and hydrogen gas can be produced using electricity generated by renewable sources. This is important as whilst Australia has sufficient fossil fuel based resources for electricity generation for more than 150 years the country is a net importer of fuels for transportation; in particular petroleum and diesel, and national oil reserves are estimated to last only until approximately 2018. With the advent of the hydrogen fuel cell which uses hydrogen to produce electricity and release no green house emissions, only water, the future is bright for hydrogen as a transportation fuel.

10.1. Electrolysis

The basic principle of electrolysis is to use an electrical current flowing through a volume of water to decompose the liquid into molar volumes of diatomic hydrogen and oxygen in the ratio of 2:1. The electrical source is connected to an anode and cathode which are generally an inert metal or alloy such as platinum, stainless steel or titanium. As the electricity is applied the oxygen atoms will accumulate on the anode and the hydrogen will accumulate on the cathode due to the relative unlike charges. The gas will then rise due to its low density to above the surface of the water where it can be collected.

Fresh water has an extremely low conductivity so often an electro-catalyst is used to quicken the reaction. The gas produced by this electrolysis unit would not be pure hydrogen but rather a mixture of hydrogen and oxygen in the same ratio of 2:1 as in water. The mixture of gasses in these proportions is known as Browns gas, HHO or commercially hydroxyl. The oxygen content is the removed using the different densities and specific gravities of the two gasses and the hydrogen is stored for distribution. The hydrogen is generally stored as a pressurised gas or a liquid.

10.2. Fuel reformation

The principle of fuel reformation is to use a fuel reformer to liberate some of the hydrogen stored in a conventional hydrocarbon fuel such as propane, LPG or methanol. It is currently the most widely used method of creating hydrogen on an industrial scale. One fuel reformer technique known as steam methanol reformation involves the reaction decomposition reaction between methanol and steam at temperatures above 800 °C.

Currently much work is focusing on fuel reformation techniques that use other hydrocarbons such as gasoline and diesel as the hydrogen source. The motivation for such work is that the reformation would provide the large volumes of hydrogen needed for the hydrogen fuel cell which seems to be the choice of power plant for the future. As the reaction takes place in an enclosed environment the unnecessary carbon monoxide and dioxide components could be kept out of the environment. The main advantage of this technology regarding fuel cells however is how established the technology and the how existing liquid and gaseous fuels can be reformed to produce hydrogen gas without emitting excess GHG emissions.

11. Future of renewable energy in Australia

The future of renewable energy in Australia looks to be promising with a renewable biofuels and biodiesel being increasingly popular. It is recommended that biofuels is continually researched and the percentage of biofuel used relative to petrol is increased to reduce green house gas emissions and reduce the reliance on foreign oil imports for transport fuel. The technology allowing biofuel to be created from feed stocks other then sugar sources such as cellulose or starch is critical as it will allow for a whole new industry of energy production on land not needed for food production.

Biodiesel is easily created from vegetable oils as well as waste cooking oil and should be increasingly utilized especially small scale producers for self use like farmers or graziers.

For electricity generation it is recommended that the current hydropower plants be continually utilised and that power generating infrastructure being integrated with all new dam and water storage developments as possible. Wind power is a significant option for electricity generation and small scale wind turbines have potential for rural communities not connected to the grid. Large scale wind farms are a good alternative to fossil based fuels if the appropriate sites can be found. Solar power should be still be used for passive water heating however large scale electricity generation is not economically viable at this point. The geothermal energy in Australia has great potential though the infrastructure and research into the field is still very much in its infancy. The investment into exploration by several large companies hints at the potential for this renewable energy technology.

12. Conclusion

In conclusion fuelled by renewed social awareness of renewable energy and the associated reduction in GHG and government legislation in the form of MRET renewable energies in Australia have a large potential. Whilst it will take significant time and effort to reduce its dependence on using coal for electricity generation, Australia has the potential to secure its long term energy future through focus on increasing utilisation of renewable energy.

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